A simple, yet still "fool-resistant," sequencer for transverters

Paul Wade W1GHZ ©2002

w1ghz@arrl.net

The availability of reasonably high-power microwave amplifiers has made switching in transverters more troublesome. At milliwatt power levels sequenced switching was not essential, and even at powers up to one watt, many operators get by without any sequencing. However, at higher power levels, like the 40-watt amplifiers for 3456 MHz which recently became available as surplus, the possibility of damaging a coaxial relay by "hot-switching" (with RF power applied) becomes significant. Even at 10 GHz, with amplifier outputs of 3 watts and more becoming common, we are pushing the hot-switch (switching with RF power already applied) capability of small SMA relays. The DB6NT[1] 10 GHz transverter MK2 instructions state: "Urgently the use of a sequence controlers is recommended."

All RF relays are capable of safely handling much more RF power than they are capable of hot-switching without damage. A sequencer ensures that the relay has time to switch before RF power is applied. Several years ago, I described[2] a "Fool-resistant" transceiver interface and sequencer, which improved some of the shortcomings of previous sequencer designs. Now that packaged transceivers (including the IF interface) for most microwave bands are readily available from Down East Microwave[3] and from DB6NT, such a complex interface is not necessary. The addition of a power amplifier, however, brings with it the need for sequenced switching.

A very attractive new IF transceiver is the Yaesu FT-817. One of its features is break-in CW – touch the key to transmit. I tested mine to see how quickly the transmitter is activated, and found it to be perhaps 10 milliseconds, not enough time for a relay to operate. Amongst the myriad menus in the FT-817 is a setting for break-in delay, but the setting unfortunately only affects the time before returning to receive, not the transmit start time.

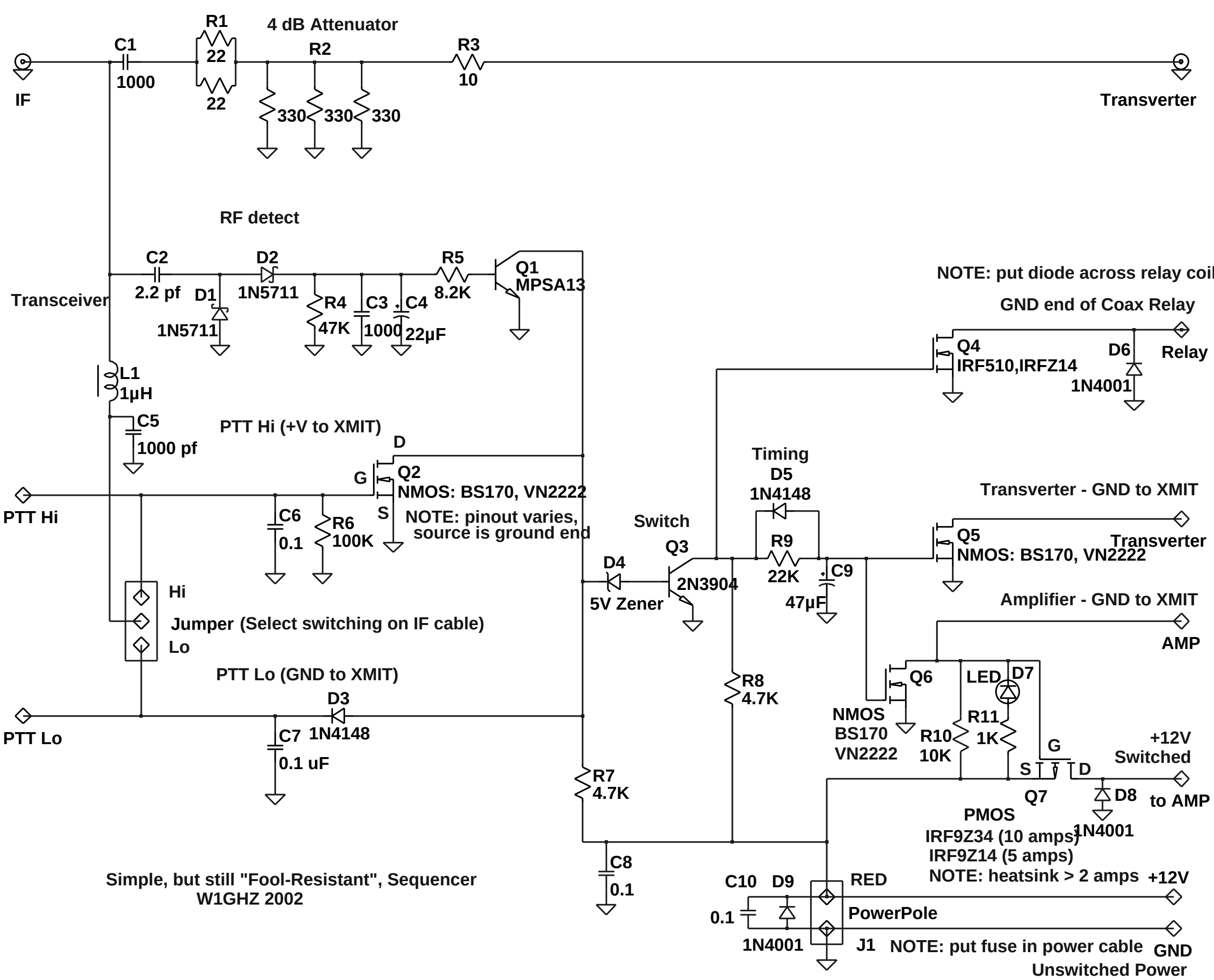
One alternative to a sequencer is to turn off the break-in feature and rely on manual switching. But how long will it be before you throw the switch with the key already closed, or start shouting before the mike button is depressed? Only a fool would say never!

For 3456 MHz, I wanted to integrate a Down East Microwave transverter with a surplus amplifier. Rather than tear apart a finished transverter to add the "fool-resistant" interface, I decided to make a small, simple, external sequencer which retains the fool-resistant functions: switch the relay before activating the transverter and amplifier, and make the switching as fail-safe as possible. One fail-safe feature is provided by RF sensing in addition to hard switching, so that even if the control cable fails (or is forgotten), the transverter will be switched safely. Since I prefer to run the control signal up the IF coax cable, I added this capability also.

The schematic diagram of the sequencer, shown in Figure 1, is drawn to separate and label functional sections. At the top left is the IF input; the RF is passed through a small 4-dB attenuator to reduce the nominal 2.5 watt output of many portable transceivers to the 1-watt level needed by many of the packaged transverters. If the control signal is on the IF cable, it is separated from the RF by C1 and L1.

There are three potential sources to activate the sequencer: *RF*, *PTT hi*, and *PTT lo*. The RF sensing circuit, between C2 and Q1, detects any transmit power from the IF transceiver and begins the switching sequence. *PTT hi* is the input for transceivers that supply a positive voltage on transmit, while *PTT lo* is the input for transceivers that ground the control line on transmit. Normally, only one of these is used in any installation, but both variations are common. The jumper is used to select whichever polarity is expected on the IF cable.

Any of the three inputs will activate the switch transistor, Q3, which will immediately drive the relay driver, Q4. After a delay time set by R9 and C9 (roughly ¼ second with the values shown), the switches for the transverter and amplifier are activated. To return to receive, all inputs cease and Q3 switches back to the receive state, turning off all outputs; diode D5 removes the delay in this direction so all outputs switch off immediately. The immediate turnoff is another fail-safe – it resets the delay time if the PTT is "stuttered" – so the coax relay may chatter but no RF will be applied so it won't be damaged. The transmit delay may be increased or decreased by changing the value of C9 – the delay is proportional to the capacitance.


4 dB Attenuator
R1 22 22
C1 1000
R2 330 330 330
R3 10
IF
Transverter
RF detect
C2 2.2 pf
D1 1N5711
D2 1N5711
R4 47K
C3 1000
C4 22µF
R5 8.2K
Q1 MPSA13
Transceiver
L1 1µH
C5 1000 pf
PTT Hi (+V to XMIT)
PTT Hi
G D S
Q2 NMOS: BS170, VN2222
NOTE: pinout varies, source is ground end
C6 0.1
R6 100K
Hi
Jumper (Select switching on IF cable)
Lo
PTT Lo (GND to XMIT)
D3 1N4148
PTT Lo
C7 0.1 uF
R7 4.7K
C8 0.1
Switch
Q3 2N3904
D4 5V Zener
Timing
D5 1N4148
R9 22K
C9 47µF
R8 4.7K
NOTE: put diode across relay coil
GND end of Coax Relay
Q4 IRF510,IRFZ14
D6 1N4001
Relay
Transverter - GND to XMIT
Q5 NMOS: BS170, VN2222
Transverter
Amplifier - GND to XMIT
AMP
Q6 NMOS BS170 VN2222
LED D7
R10 10K
R11 1K
G S D
Q7
PMOS
IRF9Z34 (10 amps)
IRF9Z14 (5 amps)
NOTE: heatsink > 2 amps
D8 1N4001
+12V Switched to AMP
C10 0.1
D9 1N4001
RED
PowerPole
J1
+12V
NOTE: put fuse in power cable
GND
Unswitched Power
Simple, but still "Fool-Resistant", Sequencer
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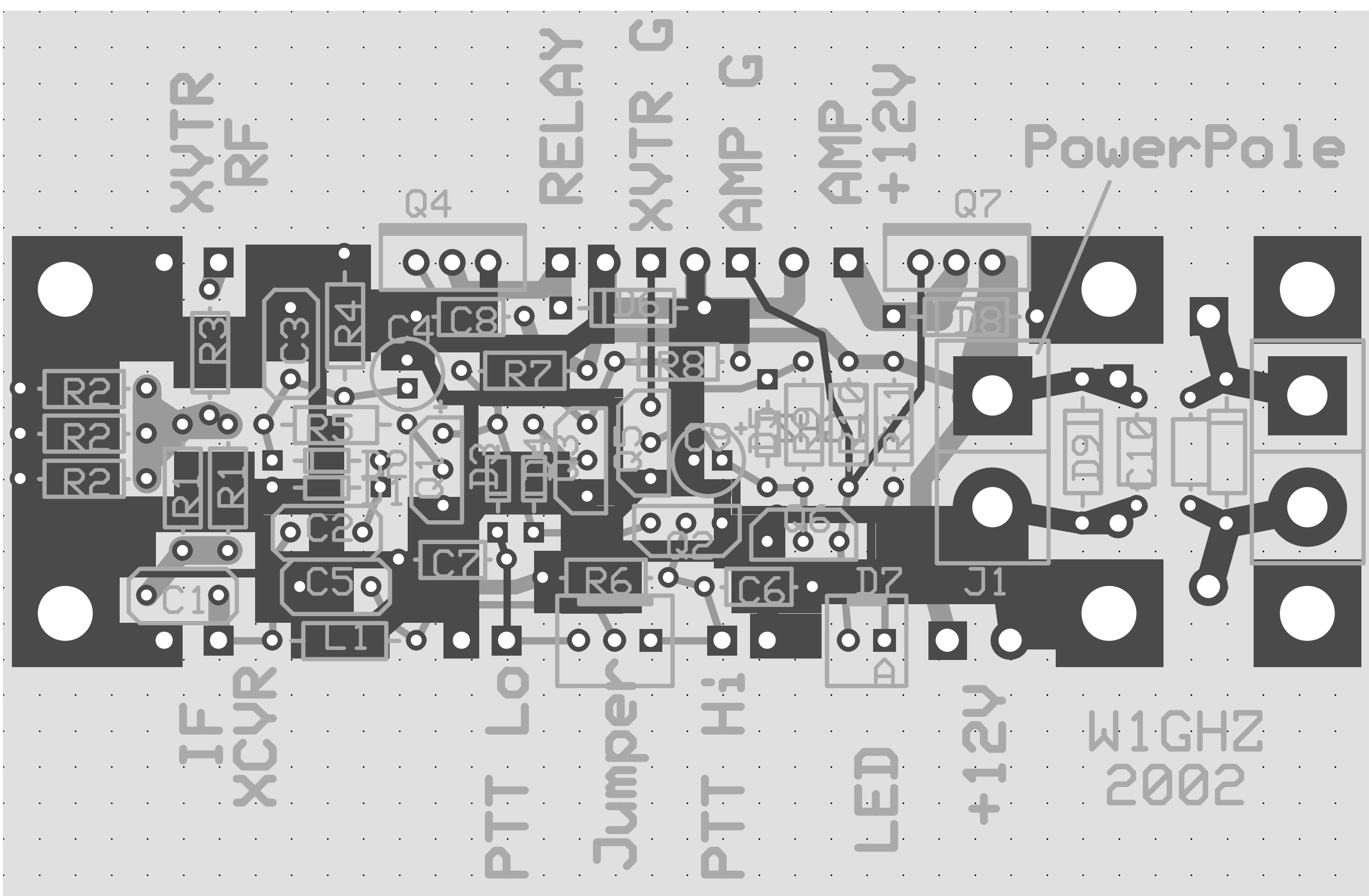
XVTR RF
Q4
RELAY
XVTR G
AMP G
AMP
+12V
Q7
PowerPole
R2 R2 R2
R3 C3 R4 C4 C8 D6 D8
R7 R8
R1 R1
R5
C2 C5 C1 L1
C7 R6 Q2 C6 D7 J1
D9 C10
IF XCVR
PTT Lo
Jumper
PTT Hi
LED
+12V
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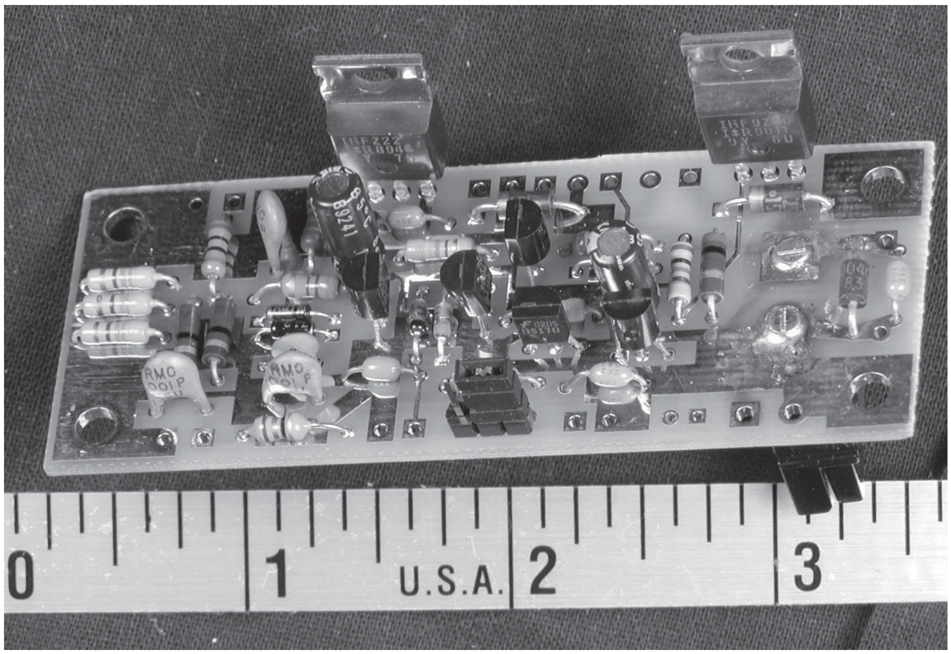
The three outputs are all FET switches to minimize size and power comsumption; the whole sequencer should only draw a few milliamps, mostly for the LED transmit indicator:

- The first output is the relay driver, Q4, an NMOS power FET which grounds the low end of the coax relay, with the other end connected to +12 or +28 volts, whatever is required. The FET is capable of driving a hefty relay, but don't forget to put a diode directly across the relay coil.
- The second output switches the transverter; a small power FET, Q5, pulls this output to ground. It is adequate to drive the small relays inside most transverters.
- The third output switches the power amplifier. Here we have two possibilities: the first, for amplifiers with a control input, Q6 pulls the terminal marked "AMP – GND to XMIT" to ground to activate the amplifier. The second, for amplifiers without any switching like those from DL2AM[4], require that the 12 volt supply to the amplifier be switched (we don't want to leave the amplifier drawing power continuously). In this case, Q6 drives a PMOS power FET, Q7, which switches the voltage with little voltage drop. The schematic lists an inexpensive FET good for 5 amps or so, and a heftier one good for 10 amps or more. If the amplifier draws more than a couple of amps, a heat sink is needed on Q7.

The circuit fits on a small printed circuit board. I included an Anderson PowerPole[5] connector for the power input in the layout, so that the sequencer can be mounted on the panel as the power connector for the complete rig. Two circuits fit on the "Miniboard" size from ExpressPCB[6], so I ordered the standard three Miniboards for $62 and ended up with six sequencer boards. The layout and connection diagram for one board is shown in Figure 2, while the file **seq2c_2.pcb** has two circuits on one board, plus two extra PowerPole patterns in some unused space at one end.



A photograph of a completed sequencer is shown in Figure 3. Construction is straightforward with common thru-hole components, and assembly goes pretty quickly. I tried to use cheap, common components so I could use one in each transceiver without pain – if you buy everything from Digi-Key[7], total cost including the PC board should be under $20. Getting the total quantity up to 100 would cut the cost in half, so let me know if you would be interested in some kits. Since the schematic is organized into functional sections, you may leave out the components for any unneeded functions.

Inclusion of this simple, easy to build, sequencer in a transverter should help to make microwave operation more fool resistant, but never foolproof.

NOTES:

1. www.db6nt.com DB6NT equipment is distributed in the USA exclusively by SSB Electronics USA, www.ssbusa.com
2. P. Wade, N1BWT, "A Fool-Resistant Sequenced Controller and IF Switch for Microwave Transverters," ***QEX***, May 1996, pp. 14-22.
3. www.downeastmicrowave.com
4. www.dl2am.de/
5. www.andersonpower.com
6. www.expresspcb.com
7. www.digikey.com